Wilson

Santa Clara County Flood Control
and
Water Conservation District

REPORT

ON

COSTS AND METHODS OF DETERMINING

GROUND WATER PRODUCTION

IN

ZONE W-1

December 1963

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and
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santa clara county

FLOOD CONTROL AND WATER DISTRICT

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TELEPHONE 299-2031

December 30, 1963

Honorable Board of Supervisors
Santa Clara County Flood Control
and Water Conservation District
70 West Hedding Street
San Jose, California

Gentlemen:

Enclosed is our final report on the "Costs and Methods of Determining Ground Water Production in Zone W-1". A first edition of this report was prepared in June of 1963 for the Agricultural Water Advisory Committee. That report was adopted in principle by the Advisory Committee. Their comments and suggested revisions, including the addendum to the report prepared for the Advisory Committee in July 1963, are included in this final report.

The Advisory Committee, after numerous meetings and considerable discussion, has resolved that the agricultural ground water production should be determined by the most economical method resulting in the highest net return of the ground water charge. To accomplish this, our report indicates that about 50 percent of the agricultural wells should be metered; these wells produce about 87 percent of the total agricultural ground water production. The remaining 50 percent of the wells, which produce 13 percent of the agricultural ground water, should have their production estimated by the correlation method most appropriate to the conditions prevailing at the individual well.

The Advisory Committee further resolved that the meters should be supplied and maintained by the District. The resolutions of the Advisory Committee pertaining to agricultural ground water production are presented in Appendix C of this report for your information.

Your concurrence in the recommendations of this report, which has been adopted by the Agricultural Water Advisory Committee as its basic policy, is requested.

Sincerely yours,

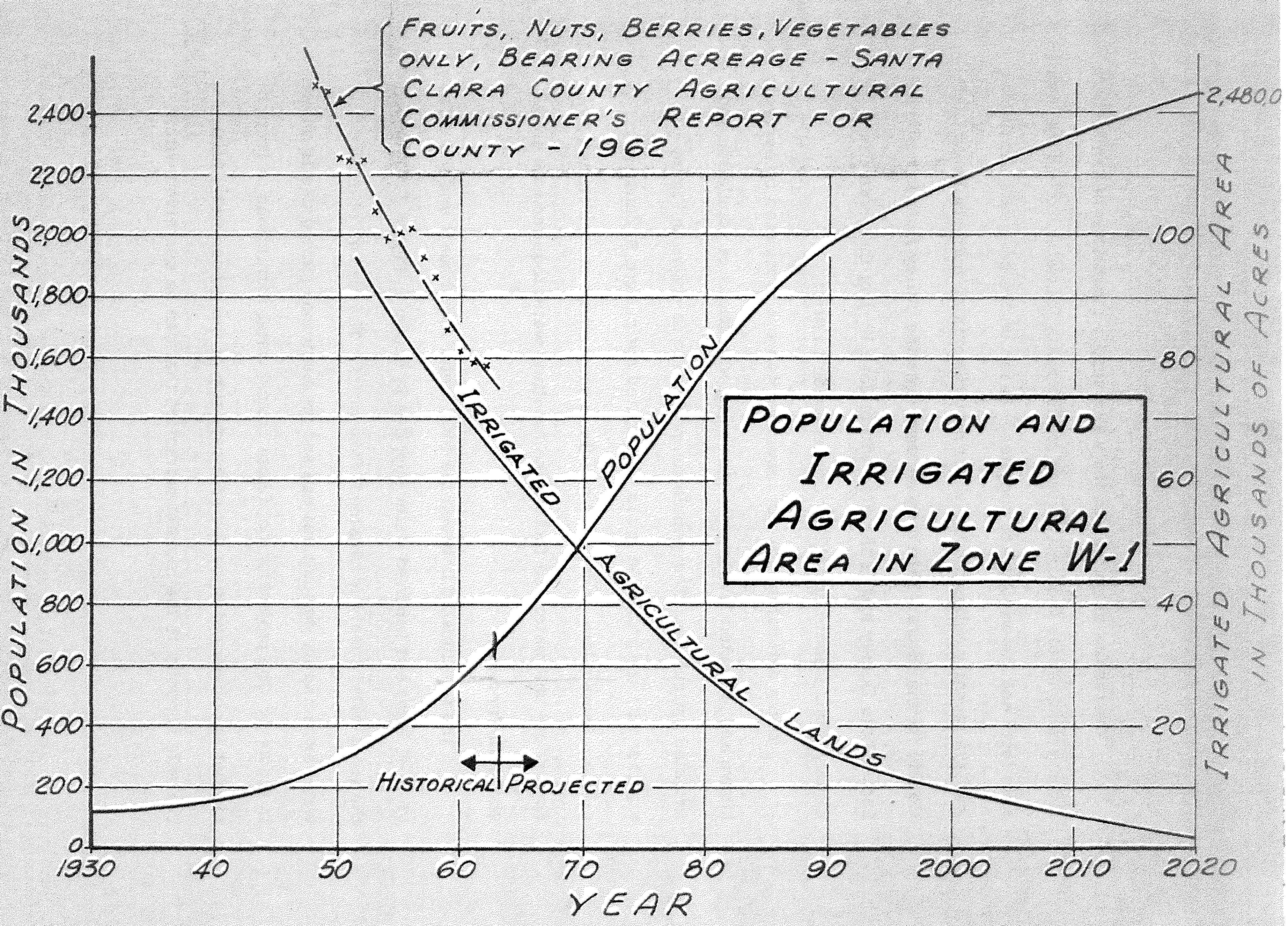
Manager-Counsel

INTRODUCTION

The results of studies of the water supply conditions in Santa Clara County demonstrate that our present requirements for water exceed the available local and imported water supplies. Based on the best data available, we have recently estimated the water requirements of northern Santa Clara County for the future. This area encompasses the valley floor in northern Santa Clara County and is the area within Zone W-1 of the Santa Clara County Flood Control and Water Conservation District.

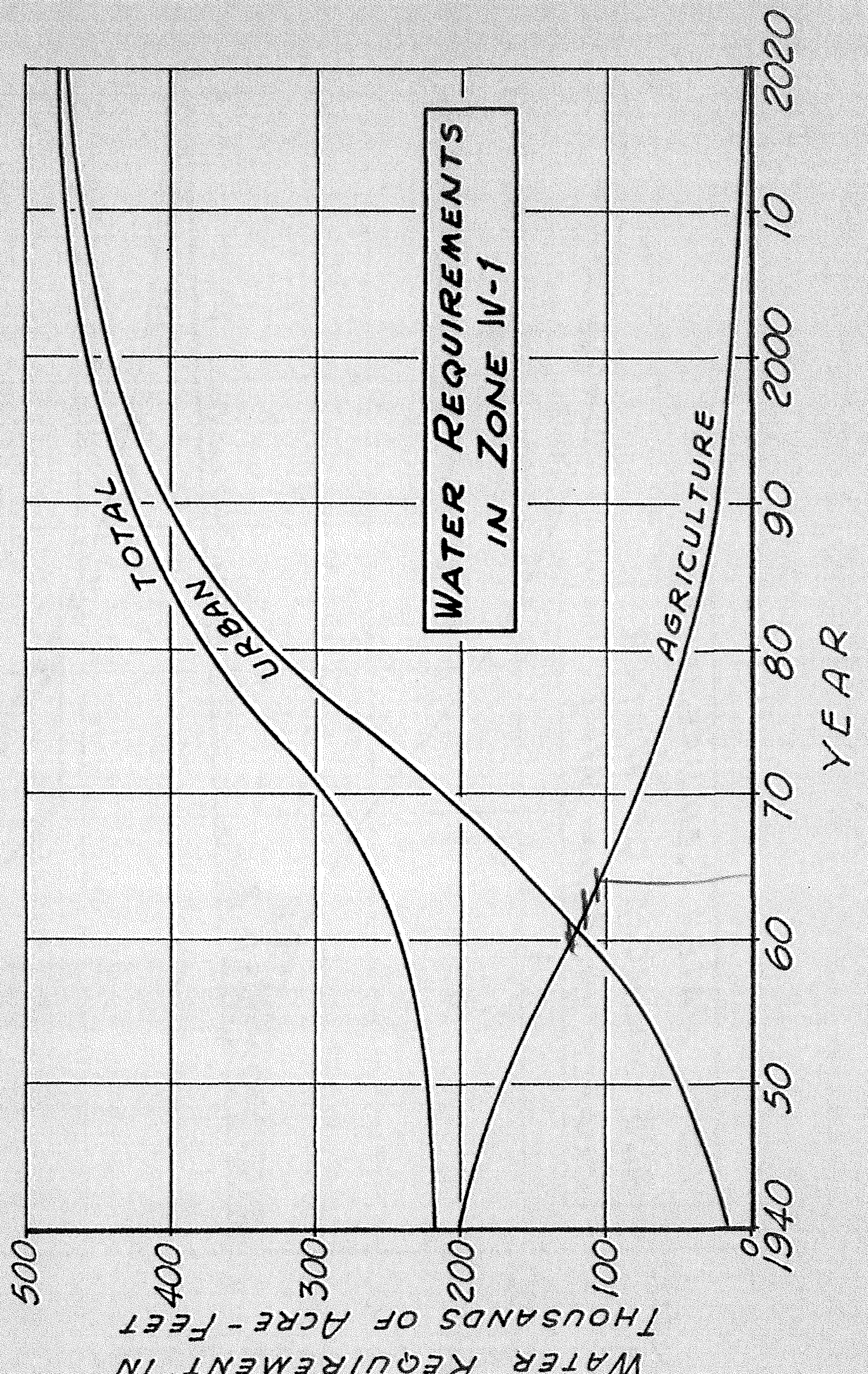
These estimates of water requirements were formulated by applying known and projected levels of water use to projections of population and irrigated agriculture. The population projection is shown in Figure 1 together with the projected areas of irrigated agriculture in Zone W-1 northern Santa Clara County. When these projections are multiplied by appropriate unit water use factors, the resulting water requirements are as shown in Figure 2.

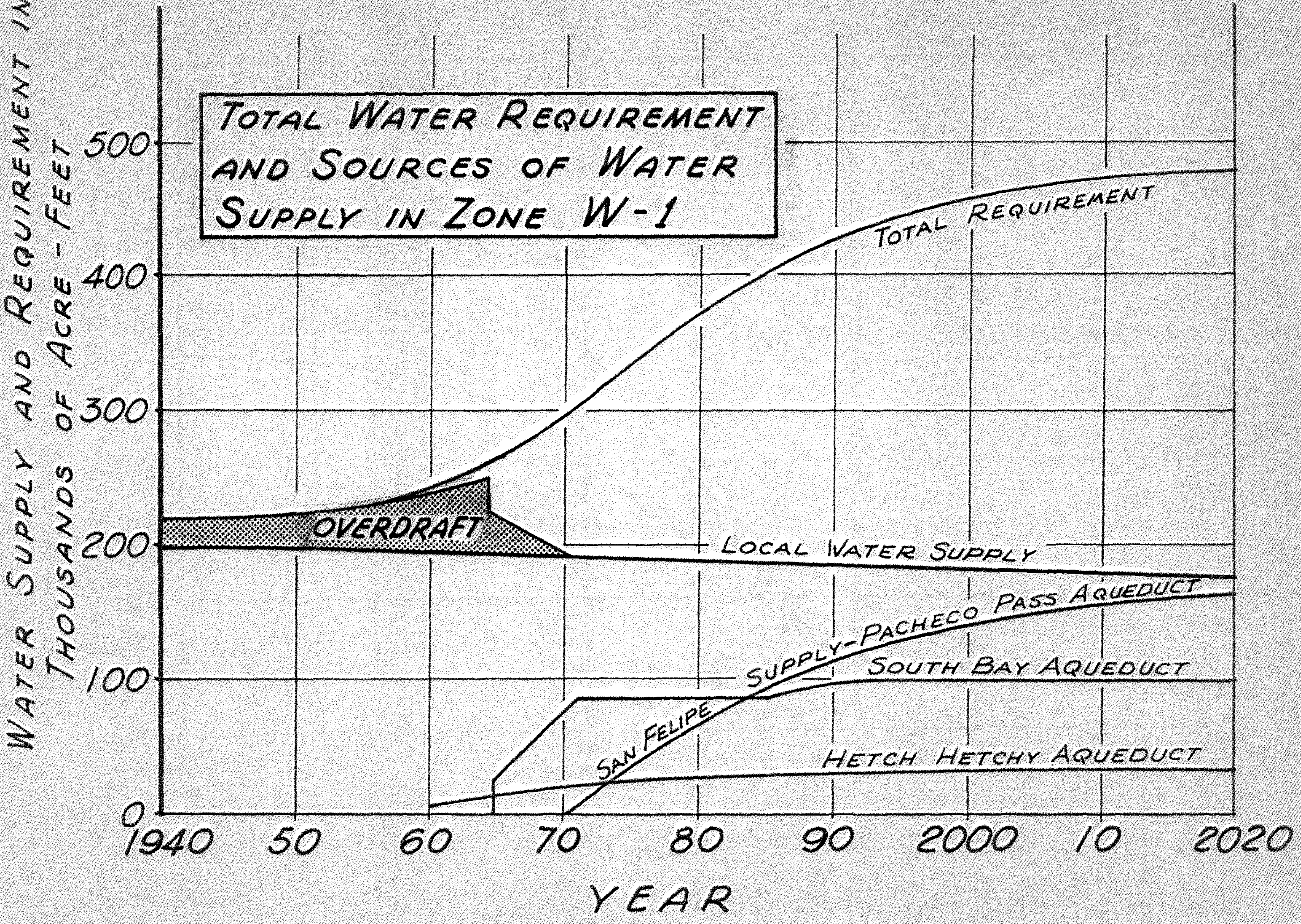
The relationship between the total water requirement and the safe yield of local and imported water supplies is shown in Figure 3. Most of the local water supply is obtained from wells. The amount of ground water extracted for agricultural use and for municipal (urban) use is shown in Figure 4. The projections of future ground water extractions is limited to what is considered to be the safe capacity of the ground water basin. The safe capacity is the highest extraction that can be sustained within



POPULATION AND IRRIGATED AGRICULTURAL AREA IN ZONE W-1

FIGURE 2


WATER REQUIREMENTS IN ZONE IV-1
TOTAL
URBAN
AGRICULTURE
WATER REQUIREMENT IN THOUSANDS OF ACRE-FEET
500
400
300
200
100
0
YEAR
1940
50
60
70
80
90
2000
10
2020



TOTAL WATER REQUIREMENT AND SOURCES OF WATER SUPPLY IN ZONE W-1

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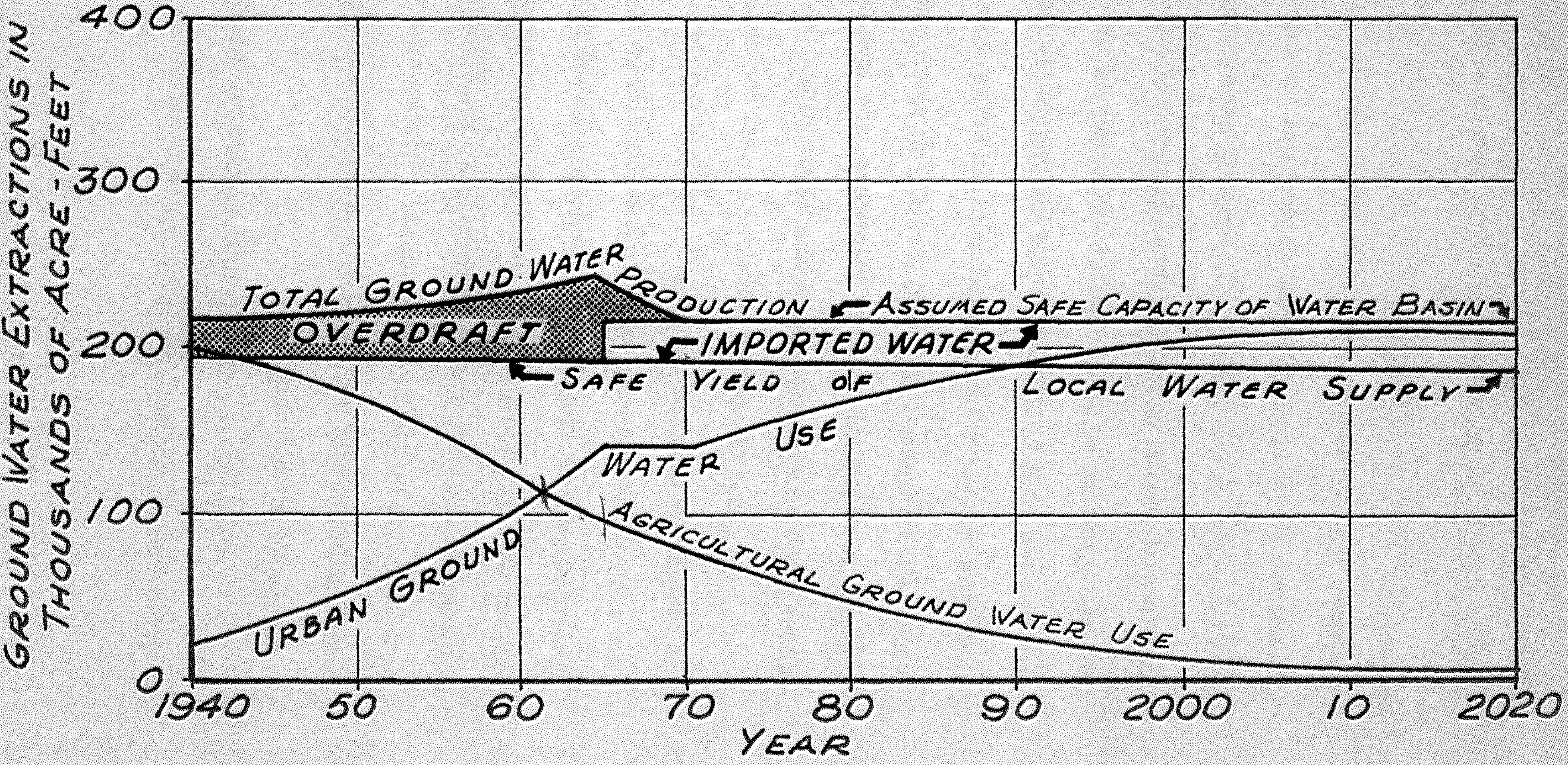
FIGURE 5

GROUND WATER EXTRACTIONS IN ZONE W-1



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the physical characteristics of the basin and under optimum recharge conditions without endangering the basin by sea water intrusion or subsidence.

The cost of importing water will be paid for by revenues from three sources. An ad valorem tax of not to exceed five cents per $100 assessed valuation will be applied to the payment of the capital cost of the aqueducts to bring water to the County. A pumping assessment not to exceed $5 per acre-foot of ground water extracted for agricultural use and not to exceed $20 per acre-foot of ground water extracted for use other than agricultural will pay the cost of the water and the In-County Distribution System needed to deliver the water to good percolation areas. In addition, some imported water will be treated and sold directly to water users. A price will be charged to repay all costs of treatment, the municipal and industrial ground water pumping assessment, and a share of the distribution lines.

In order to collect the assessment for ground water extracted, it will be necessary to know how much ground water is produced. All wells in Zone W-2 (coterminous with Zone W-1) will be located and registered so that the sources of production and uses to which the extracted ground water is put will be known. Most wells producing ground water for municipal and industrial uses are metered; therefore, the amount of production from these sources can be easily determined. On the other hand, very few of the agricultural wells are metered and ground water production can only be estimated at this time.

This report presents information on the various methods of estimating ground water production and the costs involved. The first edition of this report was reviewed by the Agricultural Water Advisory Committee and their comments as well as later information are incorporated herein.

METHODS OF DETERMINING GROUND WATER PRODUCTION

The production of ground water from wells can be determined in several ways, all of which have their own particular advantages and disadvantages. The most accurate method is to place a meter on the discharge of all wells and measure the ground water production directly. A less accurate method is to develop a correlation between some related easily measured factor and the ground water production. This section discusses metering and several practical correlation methods that may be considered applicable to conditions prevalent in northern Santa Clara County.

Metering Method

Meters can be grouped into two categories, those used in closed conduits (pipes) and those used in open channels. The various meter types within each of these categories and their essential characteristics are listed in Table 1. Not all of these meters are suitable for measuring agricultural water because of high cost. The most practical meter for agricultural use would be the propeller meter in closed conduits and the Parshall or Venturi flume in open conduits.

Correlation Methods

The District Act does not permit the application of a flat fee or acreage assessment in lieu of a per acre-foot charge; therefore, it is

TABLE 1

METER CHARACTERISTICS

Type	Accuracy in Percent (Plus or Minus)	Range of Flow in gallons per minute (gpm)	Totaliser Direct or Indirect[1]	Typical Cost Including Installation for 900 gpm (2 cfs) meter
Closed Conduits (full pipe)				
Venturi	1	1-500,000	Indirect	$ 800
Orifice	2	1-4,000	Indirect	500
Bend	2	1-4,000	Indirect	400
Propeller	3	1-500,000	Direct	250
Displacement	3	1-4,000	Direct	1,000
Magnetic	1	1-4,000	Indirect	3,000
Open Conduits				
Weirs	3	1-1,000,000	Indirect	500
Flumes (Parshall Venturi, Palmer-Bowlus)	7	1-500,000	Indirect	500
Revolving Vane	10	1-500,000	Direct	200

[1] Accumulative flow measured directly on meter by mechanical action, or indirectly on remote unit by conversion of pressure or head differential, or indirectly by computation from chart of pressure or head.

necessary to estimate the amount of ground water production from all non-metered wells. The only practical alternative to metering is to use one of the correlation methods.

The ground water production from an agricultural well can be estimated by developing a correlation between the ground water produced and some related factor such as acreage and type of crop, amount of crop, rainfall, power used, duration of operation, or a combination of several of these or other factors. For an urban or domestic well the related factors include area and type of culture (development), population, type and number of water using facilities, power used, duration of operation or a combination of several of these or other factors.

The value of a correlation method is entirely dependent upon the validity of the correlation. Unfortunately, no factor has been found that can provide a consistent correlation.

The potential errors to be expected in agricultural correlation methods are indicated by the results of studies relating various factors to water use. In a series of studies of irrigation practices in Santa Clara County, the California Department of Water Resources found in 1948 and 1949 that the measured amount of water applied to any crop type showed wide variation from the average unit of applied water. For example, prunes varied between 23 percent and 200 percent of the average value developed from 28 studies. Thus the estimate of ground water production developed on the basis of a uniform average value for the unit amount of applied water can be expected to be in similar error. The power consumption correlation shows similar variations. An example of the variation that can be expected in this correlation results from the studies of water costs by the Agricultural Extension Service. Tests made in March and again in June on wells in San Benito County indicated increases of 19, 24, 33, and 35 percent in the power required to produce one acre-foot of ground water. Thus, the accuracy of this correlation is dependent upon the time and frequency of the measurement of the related factors.

Of the several potential correlation methods investigated, those most suited to the situation as it exists in Santa Clara County were the crop-acreage, power consumption, and per capita-unit area methods.

Crop-Acreage Correlation Method

The crop-acreage correlation method is dependent upon a number of variables such as the amount of acreage, type of crop, time and duration of rainfall, soil topography, wind, the individual, and the cost of water. Because of the number of variables involved, accurate estimates of water production by the crop-acreage correlation method are difficult. However, for the estimate of ground water production from wells of small capacity, relatively large errors would be permissible since the total amount of ground water involved is small. The treating of each well individually and by using as many of the variables indicated above as possible, should reduce the potential error.

The crop-acreage correlation method requires that the average annual amount of applied water for each crop grown in northern Santa Clara County be known. This average annual amount of applied water can be adjusted to meet the individual requirements of soil, topography, rainfall, and other variables. The average annual amounts of applied water developed by the

Department of Water Resources, the Agricultural Extension Service, and the University of California at Davis that are applicable to northern Santa Clara County are presented in Table 2. These values are exclusive of precipitation and, therefore, are not to be construed as unit values of consumptive use. When multi-cropping occurs, experience has shown that about 67 percent of the sum of the applied water for the two crops is used.

These average annual amounts of applied water can be used to determine the ground water production by multiplying the unit value given in Table 2 times the acreage planted. There are problems with the use of average values that may be reduced as experience is gained in the determination of ground water production in Zone W-1.

Power Consumption Correlation Method

This correlation method uses the relationship between the power utilized and the amount of ground water produced which depends upon the pump and motor efficiency, the distance to ground water including the drawdown, and the pressure head. The major uncontrolled variable in this correlation method is the distance to ground water. However, this method, when properly applied, should develop a more accurate estimate of the ground water production than the crop-acreage method.

In the power consumption correlation method, the amount of ground water produced is measured and compared to the amount of power consumed during the production of the measured amount of ground water. These

TABLE 2

UNIT VALUES OF APPLIED WATER, AGRICULTURAL USE

Crop	Applied Water in Acre-ft/ acre/year
Grain and Forage	
Alfalfa	3.0
Clover	3.0
Pasture	2.3
Lawn	3.5
Other forage	3.0
Orchard	
Almonds	1.5
Apricots	1.5
Cherries	2.5
Vineyards (Grapes)	1.2
Olives	2.5
Pears	2.5
Plums	1.4
Prunes	1.4
Peaches	1.5
Walnuts	1.5
Mixed orchard	1.7
Truck Crops	
Asparagus	2.5
Beans, String	2.5
Beans, Lima	2.5
Beets	2.5
Broccoli	2.0
Brussel Sprouts	2.0
Cauliflower	2.5
Corn, Sweet	2.5
Truck Crops (continued)	
Carrots	2.5
Cabbage	2.0
Cantaloupe	2.5
Celery	4.0
Cucumber	2.5
Eggplant	2.5
Endive	2.5
Garlic	2.0
Kohlrabi	2.5
Lettuce	2.5
Onions	2.5
Pumpkins	2.5
Potatoes	2.5
Radishes (annual)	2.5
Sugar Beets	2.5
Strawberries	4.0
Tomatoes	2.5
Turnips	2.5
Mixed	2.5
Miscellaneous	
Ornamental Plants	2.5
Garden, Family	2.5
Nursery	3.0
Multicropped	0.67 x sum of applied water of two crops.

figures are reduced to unit values which become the relationship between power and ground water production. The power can be measured in kilowatt-hours if the driving unit is an electric motor or in volume of fuel consumed if the driving unit is a gas, gasoline, or diesel engine. Where it is not possible to obtain a direct measure of the kilowatt-hours or volume of fuel used, a time of operation meter could be installed. In this case, the correlation would be between the duration of operation and the ground water production.

As previously noted, the major variable in the power consumption method is the depth to ground water. More accurate correlations can be obtained if the depth to ground water were periodically measured during pump operation. The correlation calibration should be developed annually and with monthly measurements of the depth to ground water should result in relatively accurate ground water production estimates.

Population and Unit Area Correlation Methods

In many instances the agricultural areas have a small well producing water for essentially domestic consumption. Since this water use is not agricultural, the ground water production will be charged at the municipal and industrial rate. Generally, these wells produce small amounts of ground water and it would not be feasible to meter the discharge. For these wells, the ground water production can be estimated by a correlation method which considers the average use of water per capita (population) or by unit area of application.

The per capita water use can be estimated from the measured amounts of domestic water served in similar areas in Santa Clara County. The amount of water used per person per year depends on several variables, including the individual, the population density, and landscaping. Typical values of the per capita water use are presented in Table 3. These values are given in gallons per capita per day which when multiplied by the number of people and days of occupancy will indicate the ground water production.

Water use on a unit area basis can also be determined by using the amount of acreage, the number of dwellings per acre, the population density, and landscaping. Typical values for this correlation are also presented in Table 3. In this method the typical unit value of water use from Table 3 is multiplied by the acreage involved to obtain the estimated ground water production.

Summary

The quantity of ground water production can be determined by metering the discharge or correlating production to some related easily measured factor. The most applicable meter is the propeller meter because of low cost. Of the many correlations that can be made, those relating ground water production to crop and acreage, power consumption, or population appear to be most applicable to the conditions encountered in northern Santa Clara County.

Which method of determining ground water production will be used is a matter of economics. The costs of the various methods are presented in the following section.

TABLE 3

UNIT VALUES OF APPLIED WATER, DOMESTIC USE

USE	APPLIED WATER	
	Gal/Cap/Day(1)	Ac-Ft/Ac/Yr(2)
Estate(3)	300	2.0
Farmsteads(4)	180	1.0
Trailer Parks(5)	50	4.2
Labor Camps(6)	40	2.2

Notes:

(1) Gallons per Capita per Day

(2) Acre-feet per Acre per Year

(3) Estates assume one acre of luxury landscaping and six people in continuous residence.

(4) Farmsteads assume one acre, typical farm house, and outbuildings with five people in continuous residence.

(5) Assumes 25 trailers per acre and 2.5 people per trailer in continuous residence.

(6) Assumes 25 units per acre and 4.0 people in residence for six months.

UNIT COSTS OF DETERMINING GROUND WATER PRODUCTION

This section discusses the average annual costs per well of determining agricultural and domestic ground water production by those methods discussed in the previous section and deemed to be the most reasonable and applicable to Zone W-1 of Santa Clara County. These methods are metering, crop-acreage correlation, power consumption correlation, and population correlation. While it is recognized that costs of determining ground water production may vary from well to well and year to year, the costs discussed herein must necessarily be average costs so that comparative values are obtained.

Unit Cost of Metering

Manufacturers of propeller meters have provided estimates of meter costs, and experience of users provides a measure of the operation and maintenance cost. In quantity purchases, the cost of propeller meters varies from $135 for a four-inch meter to $230 for a twelve-inch meter. The cost of installation could vary from $10 to $100. For purposes of comparison, we can assume an average discharge of about 900 gpm and an eight-inch meter (which would cost about $170). Assuming the average installation cost to be about $80, the total capital cost involved would then be $250.

The operation and maintenance of such an installation would require at least one visit per year by an inspector who could visit and check at least four meters per day. Assuming that two inspections per year will be the practice, the time required would be about four hours per well (one meter per well) per year. The average cost per hour for labor including overhead and expenses is $7.66 (see Appendix B). The total labor cost would then be $30.64 per year per well. 4 hr X 7.66 = 30.64

Based on operation experience, the meter would have to be removed and completely overhauled on the average once every five years. Owners of meters and meter company representatives have stated that this maintenance should never exceed $60 including labor and parts; over the five year period this is an average cost of $12 per year. The annual operating cost then totals about $43 ($31 labor plus $12 maintenance).

Since the basic framework of the meter should not wear out and the wearing units would be checked and replaced at least every five years, there would be no replacement charge levied against the meter. It is included in the maintenance charge.

The total annual cost per well depends on how the first cost is amortized or paid off. The cost of the meters are to be amortized over a period of 20 years without interest; for the average installation costing $250 this would be a charge of about $12.50 per year. [illegible]

The total annual charge for metering is the sum of the inspection labor cost, annual cost of repair, and annual amortization cost. The total average annual cost per well is therefore $55.14 or about $55.

Unit Cost of Correlation Methods

As noted previously, the crop-acreage correlation method and the power consumption correlation method are considered to be the most practical for use in northern Santa Clara County. Therefore, costs for only these two methods were developed. The population- unit area correlation is to be used only on small domestic wells and is not considered to be a factor in large scale evaluation of ground water production estimates. Therefore, no unit costs were developed for this correlation method.

Unit Cost of Crop-Acreage Correlation Method

This method requires that the acreage of each type of crop irrigated each year be known. The average amount of water required by a crop can be determined, but the amount of rainfall and the time it occurs causes the amount of water applied to vary widely. In addition, many other factors influence the amount of applied water. Therefore, in order to obtain a reasonable estimate of the amount of applied water, an inspector would have to visit each well owner once a year to determine as near as possible the average result of the many variables involved. This type of estimate should have an accuracy of about ±50 percent and would require about one man-day per year. The initial contact would require a greater period of time but in later years it would be less. The average annual cost, however, at one man-day per year, would be about $61 per well.

If a less accurate estimate of the amount of applied water were acceptable, one that could be expected to have an error of about ±80 percent, the labor required could be cut in half. Again, the initial contact would require a greater period of time, but in later years it would be less and the average annual labor requirement would be about four hours per well. This would cost about $31 per year per well.

Unit Cost of Power Consumption Correlation Method

This method is perhaps closer to metering in accuracy than any other correlation method used to determine the ground water production. However, to reach an accuracy of ± 10 percent it would require a continuous record of the depth to ground water and numerous checks of the pump and motor efficiency and pressure head. If two checks of the power consumption versus the amount of water produced were made each year, one in the spring before irrigation started and one in the fall after irrigation stopped, the accuracy could be expected to be ±20 percent. A good field team of two men could test and compute the power consumption-water production relationship on two wells per day. Two field tests per well per year would therefore require two man-days. This would result in an average annual cost of about $122 per well.

16 hrs

A less accurate but more economical correlation would require one well test per year and a series of measurements of depth to ground water while pumping. This should result in an estimate of ground water production having an accuracy of about ±30 percent. One test per year (depths to ground water measured and reported by the well owner) would require one man-day of labor for an average annual cost of about $61 per well.

Summary of Unit Costs of Determining Ground Water Production

The average annual costs per well for the various methods of determining ground water production are summarized in Table 4.

In all the estimates of costs of determining the ground water production, all appropriate charges are included. For example, the costs of transportation to and from the field are included as a percentage of the direct labor costs as indicated in Appendix B. However, the costs of billing for the ground water

TABLE 4

SUMMARY OF ANNUAL COSTS OF DETERMINING GROUND WATER PRODUCTION

Method	Accuracy in Percent (plus or minus)	Estimated Annual Cost in Dollars Per Well
Meters	2	$ 55
Power Consumption	20	$122
Correlation	30	$ 61
Crop Acreage	50	$ 61
Correlation	80	$ 31

12 cc
12 mo
37 [illegible]
10

charge and posting the amounts collected have not been included since they are the same for any method. That is, once the production was determined, the procedure for obtaining and depositing revenues would be the same for any method used to determine ground water production.

From Table 4 it is apparent that the least costly method of determining ground water production is also the least accurate. It also shows, however, that the most accurate method is next to the least in cost. Which method or combination of methods to apply to large numbers of wells can be decided only by an economic analysis. The economic analysis indicates how to obtain the maximum revenue at a minimum cost. This is discussed in the next section.

COST OF DETERMINING GROUND WATER PRODUCTION IN ZONE W-1

Now that the costs of alternative methods of determining the production of agricultural ground water for a well are known, the cost of applying one or a combination of the methods available to all wells in Zone W-1 can be estimated. The first question is how many wells are involved?

Our well registration program has determined that there are about 4,300 wells in Zone W-1. Of these, 27 percent are inactive and do not produce ground water. Assuming 73 percent are active producing wells, the ground water production will have to be determined for about 3,100 wells. Of the active wells it appears that about 46 percent produce ground water for agricultural use. Therefore, there should be around 1,400 active agricultural wells (46 percent of 3,100 wells).

The 1,400 active agricultural wells produce ground water to irrigate about 63,000 acres (see Figure 1). This acreage is expected to decline to about 15,000 acres by 1990. The ground water produced by these 1,400 wells and used on 63,000 acres is estimated to be about 114,000 acre-feet in 1963 (see Figure 2 and Figure 4). This ground water production is expected to decrease to about 25,000 acre-feet by 1990.

Assuming that the ground water charge for agricultural use is $5.00 per acre-foot, the estimated extractions would produce an annual revenue of about $570,000; this would decline to about $125,000 per year in 1990.

Would it be desirable to meter all wells? We would, without question, be assured of the best accuracy. However, the cost of obtaining this accuracy would be unnecessarily high in the case of low production wells. Figure 5 shows the relationship between the amount of ground water production and the number of wells. This relationship was used in developing the cost of determining the agricultural ground water production by metering any number of wells. This cost relationship is shown on Figure 6. The average annual cost of metering all active agricultural wells would be about $77,000; 87 percent of the ground water production (50 percent of the wells) could be metered for about $38,500 per year.

How much does it cost to use one of the correlation methods? From the summary in Table 2 it is seen that the only method costing less than metering is the approximate crop-acreage correlation method. This method provides an estimate subject to an error of ±80 percent for any one well. Since it contains such a large potential for error, it must be assumed that there will be a residual error in any Zone-wide estimate of agricultural ground water production. That is, over the entire area in which such an approximate method is used,the plus and minus errors in the ground water production estimates for each well will not cancel out. The result is therefore a residual error. Since the ground water production estimates will result in a charge or cost to the well owners, it is safe to assume the estimates of ground water production will be on the low side. This will result in a loss of revenue that

FIGURE 5

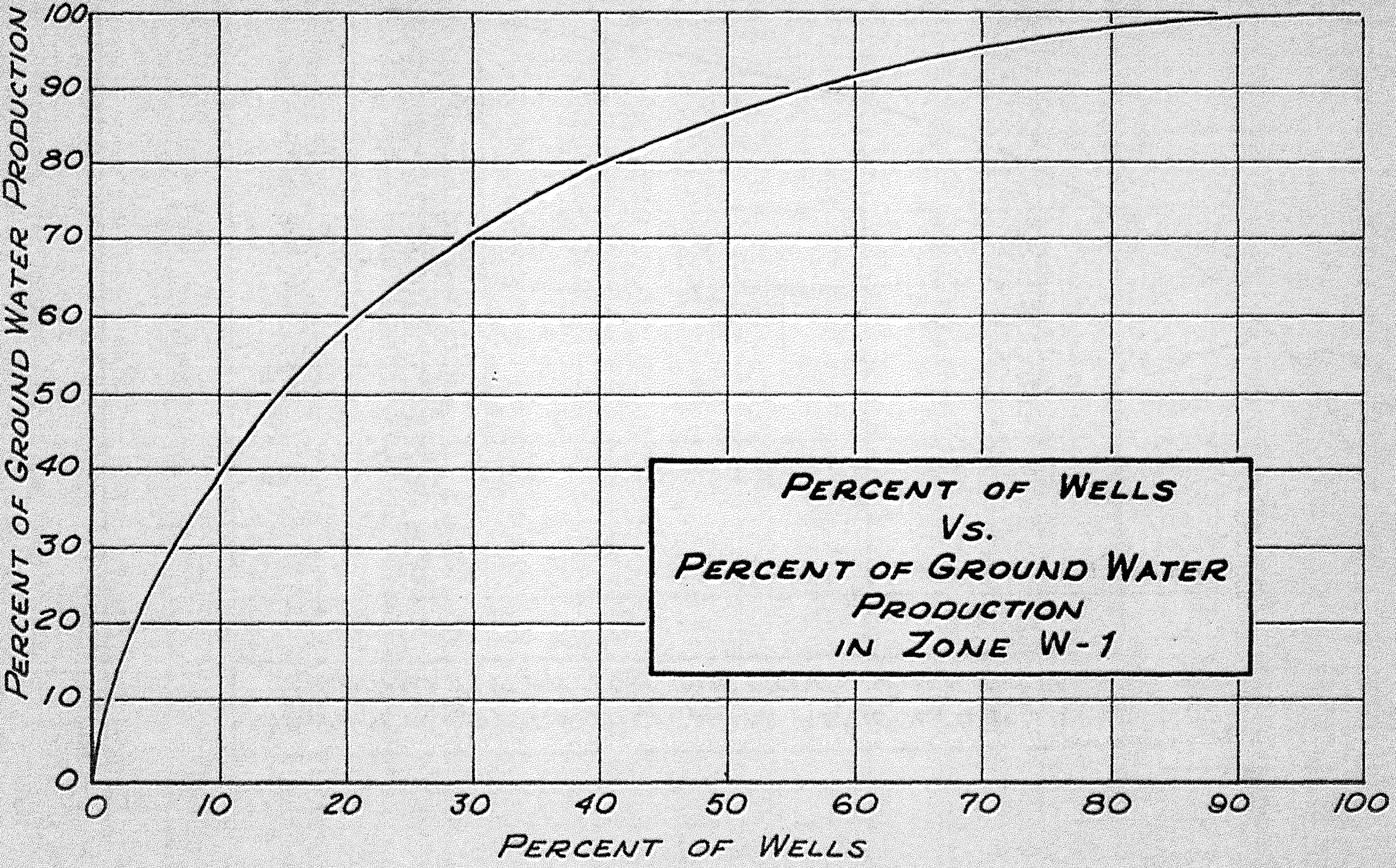
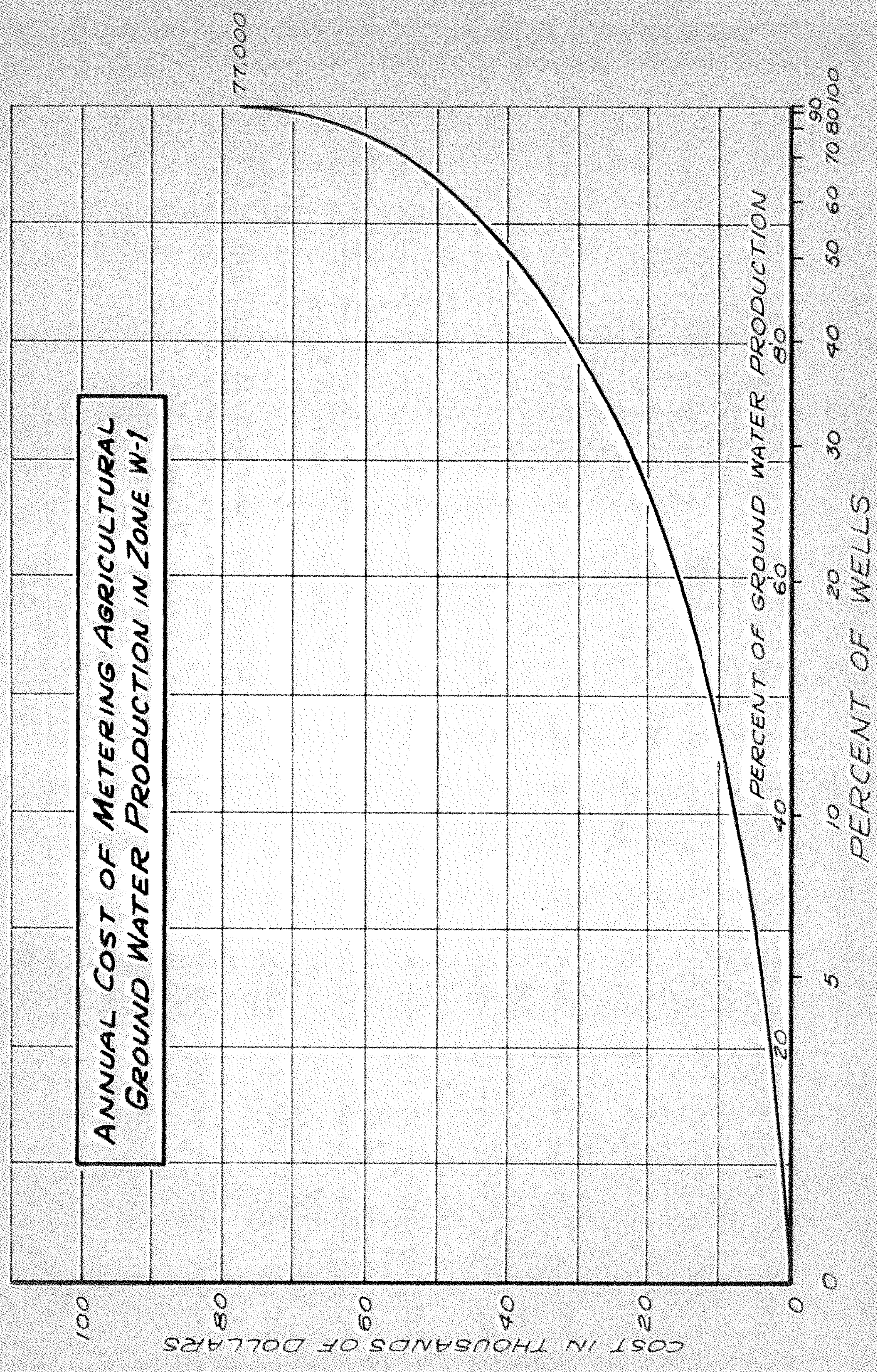

PERCENT OF WELLS
Vs.
PERCENT OF GROUND WATER
PRODUCTION
IN ZONE W-1
PERCENT OF GROUND WATER PRODUCTION
0
10
20
30
40
50
60
70
80
90
100
PERCENT OF WELLS
0
10
20
30
40
50
60
70
80
90
100

FIGURE 6



ANNUAL COST OF METERING AGRICULTURAL GROUND WATER PRODUCTION IN ZONE W-1 must be added to the cost of using the approximate crop-acreage correlation method.

The cost of estimating agricultural ground water production by the approximate crop-acreage correlation method is shown in Figure 7. If applied to all production, the average annual cost would be about $43,400 plus the residual error loss in revenue. It appears that with a potential error of ±80 percent, the residual error or loss in revenue would be around 10 percent. Therefore, the total average annual cost would be $43,400 plus $57,000 loss in revenue or $100,400.

In comparing the annual costs of determining ground water production as shown in Figures 6 and 7, it is apparent that metering is more economical for the higher production wells than estimating by the crop-acreage correlation method. This occurs because of the large potential loss in revenue which is proportional to the amount of production. However, it is also apparent from the curves in Figures 6 and 7 that the cost of determining the production by the crop-acreage correlation method would be less than the cost of metering for those wells which produce relatively small amounts of ground water. This relationship is indicated by the steeper slope of the curve in Figure 6 than in Figure 7 in the region between 80 and 100 percent of the ground water production. The steeper slope indicates a more rapidly increasing incremental cost per unit of measurement. As a result, the most economical method of determining ground water production would be a combination of the two.

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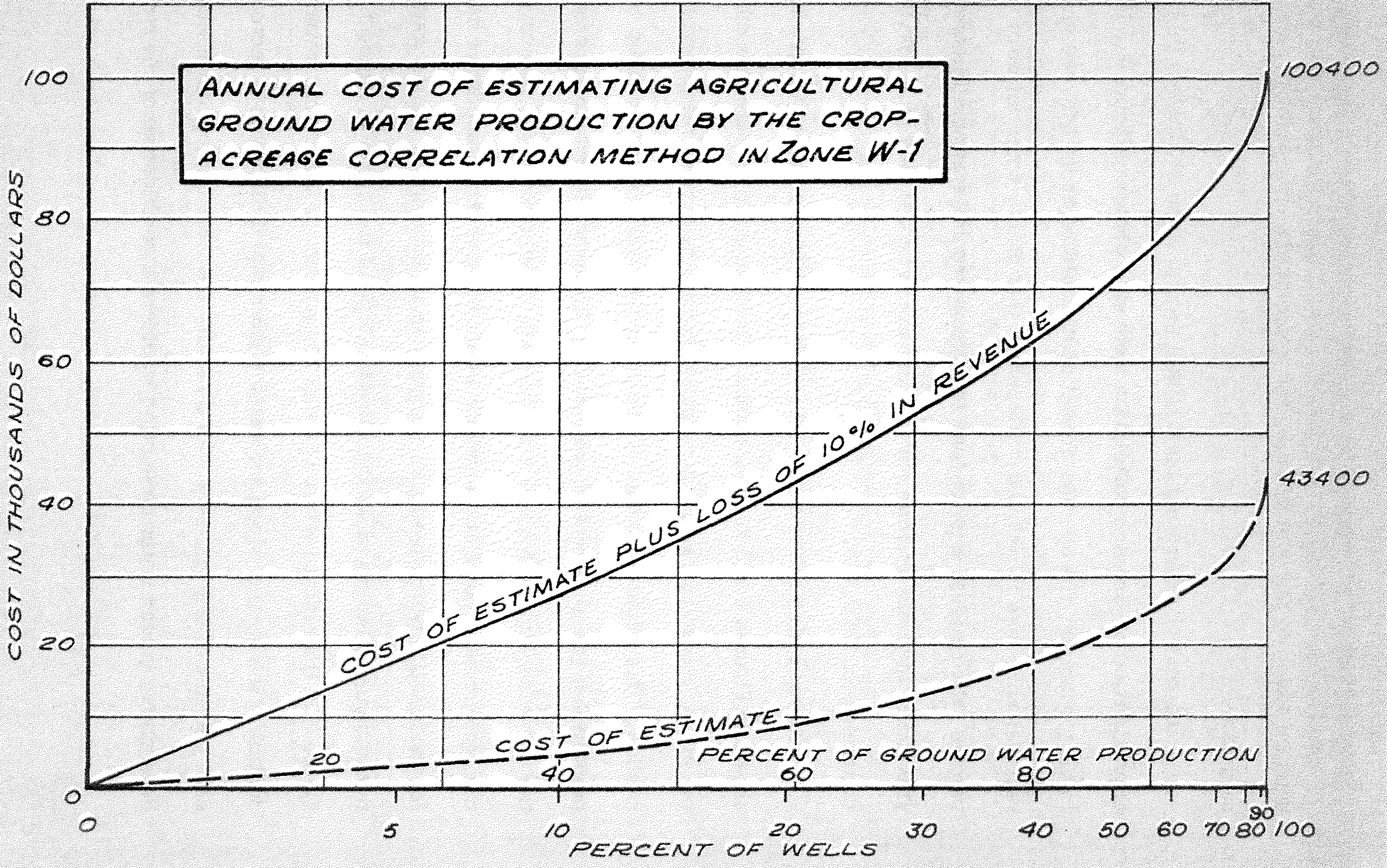
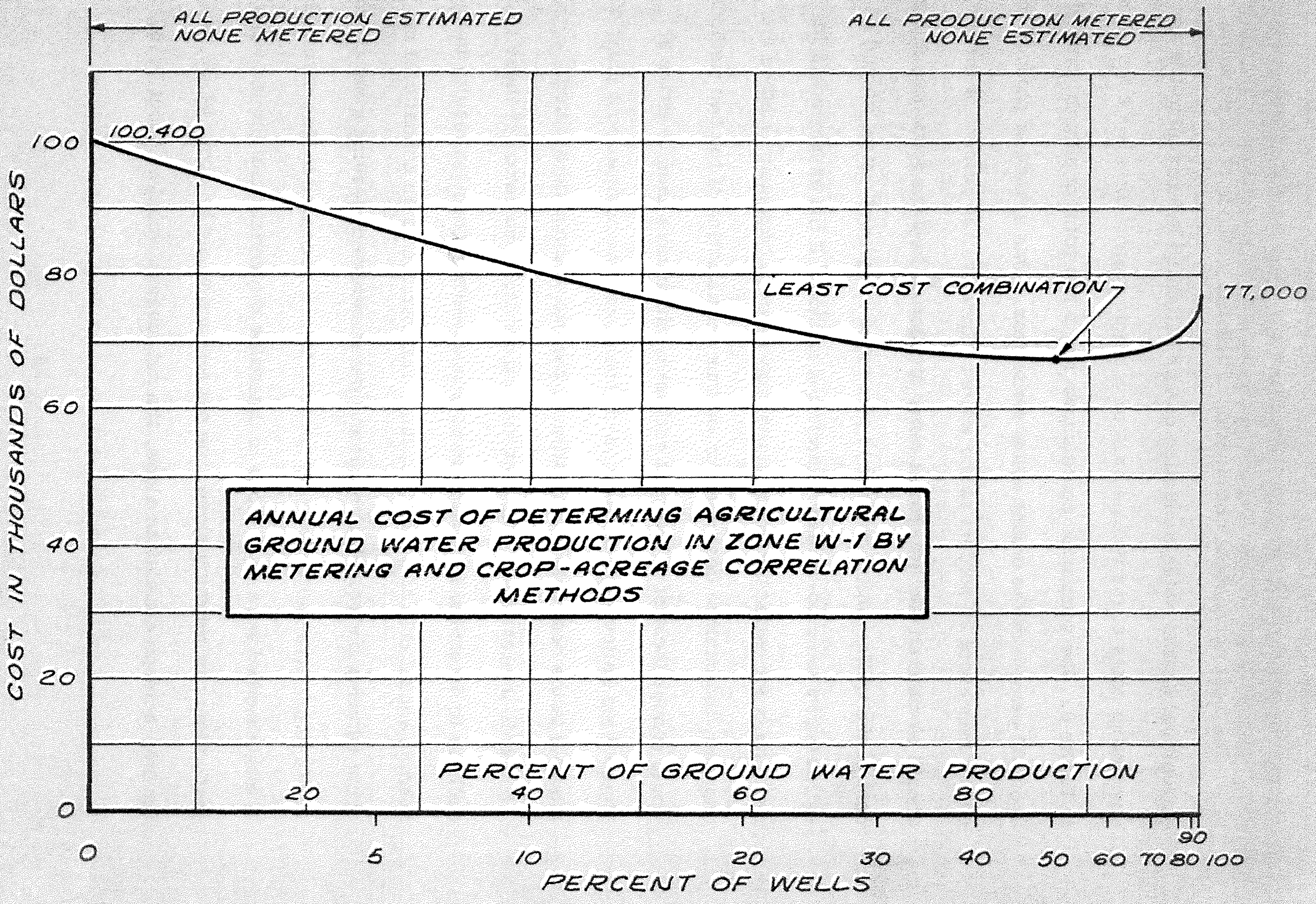
FIGURE 1



ANNUAL COST OF ESTIMATING AGRICULTURAL GROUND WATER PRODUCTION BY THE CROP-ACREAGE CORRELATION METHOD IN ZONE W-1

The most economical combination of the two methods of determining agricultural ground water production can be estimated by combining the accumulative costs of the two methods on a single graph. This has been done in Figure 8. The summation curve shown has a low point or minimal cost at about 87 percent of the ground water production. This amount of production comes from about 50 percent of the wells. Therefore, 50 percent of the wells should be metered and the ground water production from the remaining 50 percent of the wells, which produce 13 percent of the ground water, should be estimated by the crop-acreage correlation method. If the annual costs for metering or for estimating through the crop-acreage correlation method are changed, the minimal cost point or optimum combination of the two methods would change location. The cost estimates which were used to arrive at Figure 8 are believed to be valid, and, therefore, the minimal cost point of Figure 8 is the desirable combination of the two methods considered.

It is interesting to note that the appropriate combination of these two methods to determine the agricultural ground water production results in an average annual cost of about $68,000. This represents an annual cost of about 60 cents per acre-foot of ground water extracted, leaving a net revenue of $4.40 per acre-foot. This net revenue can be compared to that obtained if either method were used alone to determine the agricultural ground water production: for metering alone, the net revenue would be about $4.32, and for crop-acreage correlation alone, the net revenue would be about $4.09.



ANNUAL COST OF DETERMING AGRICULTURAL GROUND WATER PRODUCTION IN ZONE W-1 BY METERING AND CROP-ACREAGE CORRELATION METHODS

FIGURE 8

The same type of analysis as described above and presented in Figures 6, 7, and 8 can be made for any other combination of methods for determining the ground water production. Once the methods have been selected and their costs evaluated, it is possible to determine the least cost combination for any period in time. In addition, this type of analysis illustrates the size range of wells (sized by production) to which any given method of determining ground water production should be applied.

Since the analysis presented herein indicate metering of agricultural wells to be one of the more economical methods of determining agricultural ground water production, the expected future decline in agricultural wells should be considered. As wells are phased out of production, as indicated by the predicted decline of irrigated agriculture acreage and ground water extractions shown in Figures 1 and 4, the meters would be used for replacement parts and salvaged where possible. Assuming 700 wells to be metered to start with (50 percent of the wells from Figure 8), this number would be expected to decrease to around 250 wells by 1990. This gradual reduction in the number of meters needed should permit a reduction in the maintenance cost as a result of availability of parts. In 1990 when there will be about 250 wells still being metered, the annual cost of metering would be about $13,750. These 250 metered wells would still produce about 87 percent of the agricultural ground water extracted in 1990 or about 22,000 acre-feet (see Figure 4). This production would result in a gross revenue (at $5.00 per acre-foot) of $110,000 per year. The net revenue would be about $96,250 per year or $4.37 per acre-foot. It, therefore, appears that metering is economically justified for 50 percent of the wells in 1963 and continues to be so in 1990.

SUMMARY OF FINDINGS AND RECOMMENDATIONS

As a result of the study summarized in this report, the following findings are drawn.

1. The ground water charge authorized under Section 26 of the District Act required that the quantity of ground water produced from all wells in northern Santa Clara County be determined.
2. Ground water production can be determined by metering the discharge or correlating production to some related, easily measured factor.
3. The most applicable meter is the propeller meter because of low cost. The estimated annual cost of an average installation involving a propeller meter is $55 per well.
4. Of the many correlations that can be made, those relating ground water production to crop and acreage, power consumption, or population appear to be the most applicable to conditions encountered in northern Santa Clara County.
5. The crop-acreage correlation method appears to be the most desirable for use in estimating ground water production because of its low annual cost of about $31 per well. However, the exclusive use of this method can be expected to result in potentially large errors of estimate.
6. The power consumption correlation method could be used where cooperation from the owner (such as recording and reporting ground water levels monthly) results in cost reduction.

7. The population correlation method will be useful in estimating the production from domestic wells in agricultural areas.
8. Economic analysis of measurement and correlation costs indicate that about 50 percent of the wells (those of highest production) should be metered and that the ground water production of the remaining 50 percent of the wells should be estimated by a correlation method.
9. The correlation method to be used should be that most appropriate to the conditions for each well, determined on an individual basis.

As a result of these findings, it is recommended that:

1. Those facilities that produce relatively large amounts of ground water for agricultural use be metered.
2. Those wells producing lesser amounts of ground water should have their production estimated by one of the correlation methods most appropriate to the conditions encountered at the individual well, and
3. The wells to be metered and the correlation method to be used at unmetered wells be individually determined from an economic analysis by the District.

APPENDIXES

Santa Clara County Flood Control
and
Water Conservation District

APPENDIX A

PROJECTED WATER REQUIREMENTS
FOR ZONE W-1

APPENDIX A

PROJECTED WATER REQUIREMENTS FOR ZONE W-1

Year	Item	Amount	Water Requirement	Total Water Requirement
1960	Population	544,000	113,400	
	Irrigated Acreage	72,000	129,600	243,000
1970	Population	1,080,000	213,500	
	Irrigated Acreage	48,000	83,500	297,000
1980	Population	1,582,000	331,700	
	Irrigated Acreage	27,400	46,300	378,000
1990	Population	1,949,000	404,900	
	Irrigated Acreage	14,000	23,100	428,000
2000	Population	2,187,000	445,700	
	Irrigated Acreage	10,000	16,300	462,000
2010	Population	2,360,000	461,000	
	Irrigated Acreage	6,200	10,000	471,000
2020	Population	2,480,000	476,200	
	Irrigated Acreage	2,400	3,800	480,000

Note: The Total Water Requirement is the sum of Urban Water Requirement (on the line labeled "Population") and Agricultural Water Requirement (on the line labeled "Irrigated Acreage").

Santa Clara County Flood Control
and
Water Conservation District

APPENDIX B

DISTRICT LABOR COSTS

APPENDIX B

DISTRICT LABOR COSTS

Direct Labor

Supervisor (Top step)	$ 9,672.00	
Engineering Technician 1 (Top step)	8,361.60	
Engineering Technician 1 (Top step)	8,361.60	
Engineering Aide (Top step)	7,238.40	
	$33,633.60	per year for four men

Working hours per year (including vacation, holidays, and sick leave which are accounted for below) = 2,088; or four men it would be 8,352 hours per year.

Hourly labor rate = $33,633.60 ÷ 8,352 = $4.03

Indirect Costs

Administration (68 percent of direct labor) Includes vacations, holidays, sick leave, supervision, accounting, secretarial services, administrative projects	$2.74
Employee Benefits (11.2 percent of direct labor) Includes health insurance, social security, retirement (District contribution).	$0.45
Operating Expense (10.8 percent of direct labor) Includes supplies, telephone, office expenses, postage, education, insurance, printing and reproduction, automobile service.	$0.44

Total Cost Per Hour $7.66

Santa Clara County Flood Control
and
Water Conservation District

APPENDIX C

RESOLUTIONS OF THE AGRICULTURAL WATER ADVISORY COMMITTEE

1963

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MEMBERS OF THE
AGRICULTURAL WATER ADVISORY COMMITTEE

Walter Christopher

D. F. Danna

Milo Kiperash (Co-Chairman)

Ira Higgins

Peter La Barbera

William W. Lester, Jr.

Paul A. Mariani, Jr.

Nick Rajkovich

John M. Sepulveda

Ed Teresi (Chairman)

APPENDIX C

RESOLUTIONS OF THE AGRICULTURAL WATER ADVISORY COMMITTEE

Resolution on Well Registration

On January 17, 1963, the Agricultural Water Advisory Committee resolved:

1. That the Board of Supervisors of the Santa Clara County Flood Control and Water Conservation District authorize and direct that registration of wells commence immediately and to be completed in the six-month period prescribed by law; and that the District be provided sufficient staff to accomplish the well registration program.

2. That this Committee makes this recommendation as being the first step which will in all probability result in the ultimate imposition of a ground water charge.

3. That this Committee will next consider the problem of measuring ground water production, by meters or otherwise.

Resolution on Metering

On March 28, 1963, the Agricultural Water Advisory Committee resolved:

1. That the ground water production from all agricultural wells be metered where at the discretion of the District it is economically feasible to do so.

2. That the method of determination of the feasibility of metering be subject to regular review by the Agricultural Water Advisory Committee.

Resolution on Cost of Metering

On March 28, 1963, the Agricultural Water Advisory Committee resolved:

1. That the cost of the meter, installation, and maintenance of agricultural water measuring devices be borne by the Santa Clara County Flood Control and Water Conservation District.

On June 20, 1963, the Agricultural Water Advisory Committee resolved:

1. That the capital cost of the meters and installation of measuring devices on agricultural wells be amortized over a twenty year period.

2. That such amortization bear no interest.

Resolution on Adoption of District Report on Methods and Costs Determining Ground Water Production

On June 20, 1963, the Agricultural Water Advisory Committee resolved:

1. That the report of the Santa Clara County Flood Control and Water Conservation District on "Costs of Determining Ground Water Production in Zone W-1" dated June 1963, be adopted as the guide in developing the method to use in determining the ground water production from agricultural wells in Zone W-1.

2. That the report be amended to include the amortization of meters over a twenty year period at no interest.

3. That an addendum be prepared to illustrate the crop-acreage correlation method of estimating ground water production.

On July 25, 1963, the Agricultural Water Advisory Committee resolved:

1. That the July 1963 "Addendum" to the report on "Costs of Determining Ground water Production in Zone W-1" prepared by the Santa Clara County Flood Control and Water Conservation District be adopted in principal as establishing the most practical correlation methods for determining ground water production from agricultural wells.

2. That the crop-acreage correlation criteria on unit values of applied water be reviewed from time to time and revised as more data and experience becomes available.